CALIFORNIA STATE UNIVERSITY, SACRAMENTO

EXPLORATORY DEVELOPMENT RESEARCH EFFECTIVENESS

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James A. Jolly

J. W. Creighton

Thomas A. Buckles

September 1977

Prepared for: NAVAL FACILITIES ENGINEERING COMMAND, ALEXANDRIA, VIRGINIA

SCHOOL OF BUSINESS AND PUBLIC ADMINISTRATION
DEPARTMENT OF MANAGEMENT
6000 J STREET SACRAMENTO, CALIFORNIA 95819

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James A. Jolly
California State University
Sacramento, California

J. W. Creighton
Naval Postgraduate School
Monterey, California

Thomas A. Buckles
California State University
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ABSTRACT

A study was conducted to determine the transition (utilization) of the output of one category of exploratory development research sponsored by the NAVFACENGCOM Headquarters, Alexandria, VA. A detailed investigation was made about the transition of thirty work units (projects) that were selected, using a stratified random sample, from work units that had been completed during the period FY72 to and including FY76. The exploratory development research work units investigated in this study were completed at the Navy's Civil Engineering Laboratory at Port Hueneme, California.

The data from the study showed that the output of sixty percent of the work units had been transitioned. Some transitioned work units provided a product, some provided a service and yet others were the basis for further research effort. Several factors that could be important in causing successful transition were investigated. The factor exerting the most influence on the transition of the output of a work unit (project) was the amount of technology transfer effort. It was shown statistically that the likelihood of project transition was directly related to the degree of effort directed to technical reports, technical memoranda, technical data sheets and other forms of technical information dissemination and by the technical specialization. In contrast, it was found that the likelihood of transition of a work unit (project) was not significantly influenced by the years since the work unit was completed, work unit cost, or duration of the research effort on a specific work unit.

Crosstabulations of these data are included in the report. The work units studied and related pertinent data are listed in the appendix.

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Introduction

The effectiveness of a research organization has historically been measured in terms of the efficiency and productivity of the scientific personel to solve a challenging and relevant project problem. Quantitative measures such as research man-years, meeting milestone objectives, and peer evaluation of reported results are successful quantitative measures that have enjoyed acceptance for several decades. While these measures of research project effectiveness seem appropriate to the scientist, a more relevant and substantially more elusive measure of research project effectiveness, the extent of the use of the research output may be more important to the research administrator.

Research administrators and other interested executives have a need to be able to correlate research project utilization with past project selection in order to determine the effectiveness of the research project selection system. The availability of a measurement of the utilization of past research can be useful in developing a plan so that future research projects will be more likely to enjoy extensive utilization.

The mere measurement of research project utilization does not imply that there necessarily should be a high percentage of projects experiencing utilization in the short term. In fact, quite the opposite may be desirable. The output of a central research activity may only occasionally produce a product, method, or concept that will result in substantial economic reward, or be used as the basis for further development. However, it is possible that the

magnitude of the reward from a single product, method, or concept may be so large as to easily justify the research laboratory's effort for an extended, if not infinite, period of time.

The Naval Facilities Engineering Command sponsors a research program in order to develop the technology base and advanced products necessary to overcome deficiencies in technology that may affect NAVFAC's future capabilities to meet mission requirements. Most of the NAVFAC category 6.2 exploratory development is block programmed to the Navy's Civil Engineering Laboratory (CEL) at Port Hueneme, California (For details see the NAVFAC FY78 Command Management Plan.).

Objective

The objective of this study is to investigate the effectiveness of the NAVFACENGCOM exploratory development program at the Navy's CEL by looking at a sample of the completed work units and determining the number that have either resulted in a product or service or have been used as the base for further research. (This process will be referred to as, "transitioned", in this report.)

Discussion

In order to develop a profile of the effectiveness of the exploratory development program being executed at the Navy's CEL, it was decided to make a longitudinal study covering five years. The years selected were FY72 through FY76.

Each year, the Navy's CEL issues a list of completed work units. This list was used as the source of work units to be investigated. In most cases there is considerable information available about each work unit. The information consists of a DD1498 form, a final technical report (TR), a technical memorandum (TM), a technical note (TN), a technical data sheet (TS), or some combination of one or more of these technical information documents. The DD1498 and some of the other documents listed report the name(s) of the principle investigator(s) and in some cases other persons that worked on the work unit or were responsible for the coordination of the work unit.

Although it would be interesting to investigate the transitioned status of each completed work unit, time and funds determined that a sampling system was necessary. In order for a work unit to be considered for investigation it must first be reported in the completed work list. Work units that were categorized as, "assistance", or were not product oriented were excluded from the list to be considered for this investigation. Using these criteria 81 work units qualified for the time period FY72 to FY76 inclusive.

Methodology

The work unit selection was based on a stratified random sample. The stratification was by year. In order to have a sample large enough to satisfy statistical validity it was necessary to select 30 work units. The distribution of the work units selected and studied is shown in figure 1.

(FY) YEAR	NUMBER QUALIFIED	NUMBER SELECTED	NUMBER INVESTIGATED
1972	8	7	7
1973	12	10	8
1974	12	10	5
1975	16	10	4
1976	33	10	6
Total	81	47	30

Figure 1.

Distribution of work units qualified, selected and investigated.

Work units were selected by a random number process. A number larger than 30 was selected in order to assure that it would be possible to obtain the minimum sample size needed for the study. An attempt was made to investigate all selected work units. Those not investigated were attempted, however, because of travel and vacations some of the project leaders or principle scientists were simply not available. Because of this problem only 30 were investigated.

The investigation was started by obtaining the DD1498 for each of the selected work units. In addition a copy of available TRs, TMs, TNs and TSs were obtained from the Navy's CEL. These technical data were used to provide information about the technical aspects of the work unit and also to provide the names of the persons that were to be contacted in order to learn about the degree of transition of the work unit. The plan was to conduct an extensive interview with a scientist or engineer who was intimately familiar with the work unit.

In order to assure that the interview was effective and uniform a questionnaire was developed. The questionnaire, used as a guide during the interview, was filled out by the interviewer during and immediately following the actual interview. A copy of the questionnaire may be found in the appendix. The questions were direct and concise. For example the first question simply asked, "Do you know if the research project results have been applied?". The second question, "Who used it?", also demonstrates the direct and simple approach. Nine questions were used to probe the depth and extent of transition of each of the work units that were investigated.

Mr. Gene Early of the Navy's CEL Field Engineering Service Office (FESO) assisted in the preliminary tests that were used to validate the questionnaire.

All of the interviews were by telephone. As many call backs as necessary were used. The telephone interview was completely open-ended and in many cases the interview lasted in excess of 30 minutes.

Results

The degree of transition of the work units was divided into three categories: "Yes", "Potenital", and "No". The "Potenital" category was defined as the condition where the project results were not currently in use, but there was strong belief by the person interviewed that the project results would be used in the future. Figure 2. presents the results obtained from the interviews. The percent transitioned was 60%. A complete list of the projects investigated is included in the appendix. Title, accounting number, technical information numbers and approximate project cost are shown.

	TRANSITIONED CATEGORY			
	YES	POTENTIAL	NO	TOTAL
Number of projects (work units)	18	5	7	30
	60%	16.6%	23.4%	100%

Figure 2.

Number of projects in each of the transitioned categories.

The table shown in figure 2. gives the results of the study in terms of the transitioned characteristics of each of the work units as reported by the scientist or engineer most familiar with the utilization.

Several factors could possibly influence the rate of transition. One of these factors is what may be defined as the technology transfer effort. It was hypothesized that the more technology transfer effort, the more likely it would be that a project would receive transition. The technology transfer effort was divided into three levels; "Low", "Medium", and "High". If only a single report was written, then the work unit was considered to have a low technology transfer effort. If two reports were written, then the work unit was classified as having medium technology transfer effort. Work units that had two or more written reports and additional promotional effort such as a video display, journal article or similar effort were classified as high. A tabulation of the work units classified according to technology transfer effort is shown in Figure 3.

TRANSITIONED CATEGORY

Relative Technology Transfer Effort	YES	POTENTIAL	NO	TOTAL
HIGH	6	1	1	8
MEDIUM	5	1	1	7
LOW	7	3	5	15
TOTAL	18	5	7	30

Figure 3.

Transitioned category vs relative technology transfer effort.

The table shown in figure 3. reports the results of the investigation directed at determining the importance of technology transfer effort in terms of causing a work unit to transition.

Even without a statistical test it is apparent from a study of figure 3. that the technology transfer effort appeared to influence the probability that a work unit would be successfully transitioned. This was varified by applying the Chi-Square statistical test. The test indicated a better than 99% confidence that there was a difference between the distribution of the transitioned categories when grouped according to the degree of technology transfer effort.

Another factor that was studied in the analysis of the survey data was the relationship of technology specialization and its possible implication in terms of causing a work unit to transition. It seemed that technological interest and/or technological emphasis could vary depending upon the mission needs of the NAVFACENGCOM. A crosstabulation of these data is shown in Figure 4. The Environmental Protection and Energy Systems work units are included as part of the Shore and Harbor Facilities category.

It is apparent that the distribution of transitioned categories is different for each technology specialization. Ocean Engineering holds the most favorable position. The differences in the distribution of the transitioned categories were compared statistically. The Chi-Square statistical test indicated very significant difference. (There was a 98% confidence level that the distribution of the transitioned categories was different.)

		TRANSITIONED CATEGORY			
		YES	POTENTIAL	NO	TOTAL
Technology Specialization of Work Units	Shore & Harbor facil.	6	2	4	12
	Ocean Engineering	9	1	2	12
	Adv. Base Amph. facil.	3	2	1	6
	Total	18	5	7	30

Figure 4.

Transitioned category vs Technology Specialization of the Work Units.

The above crosstabulation shows the relationship between the area of technology specialization of the work units and the determination of the transitioned category.

It was hypothesized by some knowledgeable people that the transition rate of the work units should be best for earlier years (i.e. FY72 or FY73) simply because there would have been a longer time period for the transition to occur. This hypothesis does not seem to be true. The data are presented in Figure 5. The distribution of the transitioned categories was tested by using the Chi-Square statistic. There was no significant evidence that the year to year distribution was different from that expected by simple random variation.

		TRANSITIONED CATEGORY			
Year	Years ago	YES	POTENTIAL	NO	TOTAL
(FY1972)	5	5	0	4	7
(FY1973)	4	3	0	4	7
(FY1974)	3	4	1	0	5
(FY1975)	2	2	0	1	3
(FY1976)	1	4	3	1	8
	Total	18	5	7	30

Figure 5.

Transitioned category vs Years in which the Transition occurred.

The crosstabulation shown in Figure 5, above, is an investigation of the longitudinal effect upon transitioned categories. The data do not support the belief that older projects have a higher probability of enjoying transition.

Another way that a work unit can be classified is by the dollar effort. It was hypothesized that higher dollar effort work units would received more scientific and administrative attention and thus would be favored for the likelihood of transition. When tested the data did not support this contention. The data are shown in Figure 6.

	TRANSITIONED CATEGORY			
Work Unit cost	YES	POTENTIAL	NO	TOTAL
0 to $49,999	6	2	2	10
$50,000 to 99,999	5	1	4	10
$100,000 & above.	7	2	1	10
Total	18	5	7	30

Figure 6.

Transitioned Work Units by category vs Work Unit Cost in Dollars.

In the three by three crosstabulation shown above the objective was to investigate a relationship between Transitioned category and Work Unit Cost. The Work Unit cost was divided into classes of equal number. The data did not support the contention that Work Unit cost influenced the degree of transition.

There existed the possibility that the length of time that a work unit was in process in the research laboratory could be an influencing factor in the degree of transition of that work unit. With this question in mind a crosstabulation of the data was constructed. A study of the crosstabulation, however, made it clear that it was not possible to show a relationship between

the degree of work unit transition and the length of time that a work unit was in process in the research laboratory. The distributions were tested using the Chi-Square statistic. The statistical test agreed with the intuitive observation. Figure 7. shows the crosstabulation.

	TRANSITIONED CATEGORY			
YEARS TO COMPLETE	YES	POTENTIAL	NO	TOTAL
0 to 2.5 years	8	2	4	14
2.6 or more	10	3	3	16
Total	18	5	7	30

Figure 7.

Transitioned Work Units by Category vs Years to Complete a Work Unit.

The crosstabulation was made to compare the effect, if any, of the duration of a work unit with the likelihood of that unit being transitioned. As can be seen there is no obvious relationship.

Conclusion

A longitudinal study of the work units (projects) completed during a five year period at the Navy's CEL (FY1972 to FY1976 inc.) was completed. The study investigated 30 separate work units that had been selected using a stratified random sampling procedure. When the data were collected and analyzed they indicated that a 60% transition had been accomplished for the work units investigated.

There is some danger in projecting these findings to the total population of work units completed at the Navy's CEL, i.e. some degree of conservatism

in projecting the results is advisable because: (1) The study spans a five year period. (2) The stratified random sample size was relatively small (30 units total). (3) Perhaps most important, the findings may be influenced by the personal opinions of the engineers and/or scientists who were assigned to the various work units. They were interviewed in order to obtain the data.

If one is willing to accept these warnings of conservatism, then it seems reasonable to look beyond the initial findings. The other findings were as follows:

(1) There is a direct relationship between the degree of technology effort, as applied to a completed work unit, and the likelihood that the output of that work unit will be utilized.

(2) The technology specialization of the work unit appeared to influence the likelihood that a completed work unit would be transitioned.

(3) Time did not seem to be important. That is, projects or work units completed several years ago were not more likely to have enjoyed transition than the most recently completed work units. Further, the length of time that it took to complete a work unit did not appear to influence the likelihood of transition. However, recent technology transfer effort may influence the likelihood of transition.

(4) There was no indication that work unit cost was an influence in the transition process. It appeared that low cost work units experienced the same or nearly the same percent of utilization as much more expensive work units.

This study seems to support the contention that technology transfer is more the result of a positive overt effort than the result of a unique or outstanding technological discovery. So long as the technological discovery is recognized by qualified scientists and engineers as offering something

useful and desirable, the rate of utilization of that technology can be effectively enhanced by increasing the technology transfer effort.

Recommended Future Studies

1. In this report 6.2 exploratory research work units that had transitioned were identified for the period FY72 through FY76. A possible next step would be to study further each transitioned work unit in order to estimate the economic worth or benefit to the Navy, DOD, and/or other sectors of the economy. The estimated economic worth could be compared to the NAVFACENGCOM investment and an estimated return on investment (ROI) could be calculated. The study could also consider the economic benefit of technology transfer effort. Work unit transition benefit divided by technology transfer effort would give an index of technology transfer effectiveness in terms of ROI.

2. Some work units did not transition to utilization or to further research. It is possible that a study of these work units could reveal useful information as to what would be needed in order to cause transition. The degree and appropriateness of the technological advance, the logic of the timing of the research, the market interest in the research output, and the technology transfer effort are but a few of the factors that could be usefully investigated.

3. Among users of the output of the Navy's CEL are the Field Engineering Divisions (EFD's) of the NAVFACENGCOM. Each EFD is staffed with a number of qualified engineers. These engineers constitute a population that could be queried in order to determine the CEL work unit transition from the point of view of the EFD's as a user. This view of the Navy's CEL, from one segment of the market place, could be useful in terms of future project selection decisions by the Headquarters, NAVFACENGCOM.

4. There is evidence that technology from the Navy's CEL is being transitioned to other DOD agencies, Federal and State agencies, the public sector and the private sector. The amount of technology developed by the Navy's CEL and used by other DOD agencies, the Federal and State agencies, and/or the public/private sector is one indicator of the economic worth of the laboratory. The magnitude of this type of transition is not known.

A study approach that would provide a starting point and a foundation for detailed investigation would be to track the requests for literature generated as a result of research work at the Navy's CEL. Records are available at the National Technical Information Service (NTIS) and at the CEL. Technical reports generated by the CEL are placed on file with the NTIS. Once on file with the NTIS these technical reports become available to other DOD agencies, the Federal and State agencies, and the public/private sector. The NTIS retains records that list the dates of all requests, the date that the NTIS released the information, the name of the agency or firm making the request, and the name of the person designated to receive the technical report. The privacy act does make it impossible for the NTIS to release the names of private individuals making requests for technical reports, however, aggregate totals are available. Similar information is on file at the Navy's CEL concerning requests that have been sent directly to the laboratory for reports and technical information.

The initial data from the NTIS and the Navy's CEL would offer the opportunity to determine the technology that has generated the most interest. Further, a study directed at tracing either selected cases or selected technology should provide a wealth of information about interest, end use, and economic worth of technology generated by the Navy's CEL.

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NAME: _____ PHONE NO.: ___ _____

DESCRIPTION OF PROJECT:

_____

_____

_____

1. Do you know if the research project results have been applied:

YES_____ NO_____

2. Who used it:

_____ _____

_____ _____

_____ _____

3.Where was it used:

_____

_____

4. When was it used:

_____

_____

5. What efforts were taken to make the results available to potential users:

TN	_____	Journal Article	_____
TR	_____	Seminar Paper	_____
DS	_____	Television	_____
VIDEO	_____	Newspaper	_____
RADIO	_____		

6. What types of benefits occured through its use:

Dollars Saved	_____	Less Training Required	_____
Labor Saved	_____	Technological Advance	_____
Longer Life	_____	Maintainence	_____
Safety	_____		

7. Were the results used for any further research efforts:

_____

_____

_____

_____

8. Do you know of any other people we could contact who might know of any application of the project results:

_____	_____
_____	_____
_____	_____

9. In your estimation, name three recent (1972 to present) research projects that have had/are having the most(best) acceptance by the research community, the other branches of the Armed Forces, the DOD, those in the field, the business community, etc.

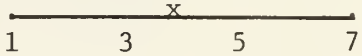
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

WORK UNIT DESCRIPTION

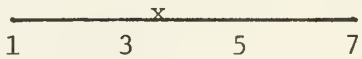
TRANSITIONED WORK UNITS (18 total)

The "x" on the scale that is marked from one to seven, which accompanies each work unit description, is used to display the technology transfer effort associated with that work unit. The one on the left of the scale indicates low technology transfer effort while the seven on the right indicates high technology transfer effort.

1) Stress Analysis of Navy VLF (very low radio frequency) Antenna Insulators. TR 839. (YF 53.534.011.01.001 F)
$56,747
Used to improve the design of insulators for Navy ULF antennas at Annapolis, Lualualei, and other locations.

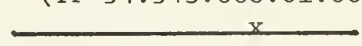


2) Study of the Dynamic Behavior and Resistance of Prestressed Beams. CR 72.016; TR 707; TR 721. (YF38.534.001.01.009)
$153,961
This project has transitioned to 6.3 research.

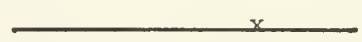


3) Underwater Repair of Electromechanical Cables in situ as Opposed to Resurfacing Before Effecting Repairs. TN 1437; TDS 75-29; (YF 52.556.003.01.009)
$7,805
Used in SEACON II project. Also DOD interest.

4) Evaluation of Shrinkable Splice Covers for Underground Distribution Cables (600-volt). TN 1325* TR 835; TDS 74-03. (YF 54.543.008.01.005
$19,167
Used by Navy and Bureau of Mines.

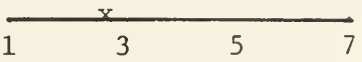


5) Determining Significant Properties of Near-shore and Inshore Underwater Sites fpr Submarine Cable Installations. TN 1323. (YF 53.535.001.01.006A)
$54,505
Currently being used by the Navy to survey nearshore cable sites.

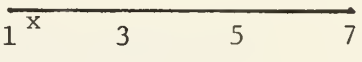


6) Develop a RDT&E Plan on the Dynamics of Cable Systems Suspended in the Ocean. (YF 53.535.004.01.008)
$12,919
Used by Navy for cable system to moorings.

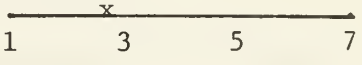
7) Develop Satisfactory, Non-leaking Seals and Gaskets for Closing Openings and Penetrations in Navy Seafloor Structures. YF 38.535.005.01.008)
$216,591
Used by Navy contractors on sea floor project.



8) Testing of High Flotation Tires to Determine Suitability for Use in Cargo Transporting Vehicles in Snow-covered Polar Regions. TN 1405. (YF 52.555.002.01.002)
$335,792
Used by Navy and Air Force. Also used by private sector in Northern California for tractors and sand vehicles.



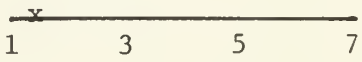
9) To Develop the Capability and Equipment to Unload a Containership in an Open Sea Environment. TN 1313. (YF 53.536.005.01.010 A)
$18,416
Floating crane concept used by Navy, Army, and Marine Corps, Fort Story, Virginia, joint tests.



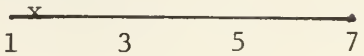
10) Construction Guide Outlining Procedures Necessary to Build and Preserve Snow Roads by Means of Layered Compaction. TR 819. (YF 52.555.001.01.001)
$474,037
Snow roads used in antarctic, arctic, Alaska, and by the Canadian government.

11) Investigating Expedient Deep-water Propellant Anchor Mooring Systems. TN 1413; TR 832; TDS 75-16. (YF 53.535.004.01.006)
$60,793
Used by Navy at Diego Garcia (18 anchors) and in rescue work off Bermuda. Private sector use by oil industry for off shore platforms.

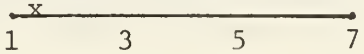
12) A Study of Electrical Safety In Naval Hospitals. TN 1275*. (YF 53.534.006.01.023)
$66,006
Developed general purchasing specifications for Navy hospitals. Some use by National Fire Protection Association.



13) An Investigation for an Improved Water Emulsion Marking Paint for Military Asphaltic Runways. (YF 51.543.006.01.014)
$7,931
Resulted in a GSA specification. Used by tri-service and some Federal agencies.



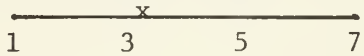
14) Plan An Energy Program for Naval Shore Facilities and Remote Bases. (YF 53.534.006.01.031)
$85,547
Concepts were used as basis for energy conservation program at Port Hueneme facility.



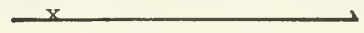
15) To Develop a Method to Produce an Antifouling Marine Concrete. TN 1392; TN 1402. (YF 54.593.007.01.001)
$335,134
Widely publicized by presenting technical papers and Journal articles. Large range of use within Navy and by others.

16) Modification of a Pneumatic Track Drill for Underwater Use by Divers. TN 1339. (YF 53.535.003.01.014)
$9,971
Used in equipment pool at CEL to support research.

17) Development of Prefabricated Panels for Rapid Fortification by Mobile Marine Forces. TR 770*; TR 1226. (YF 53.536.001.01.001)
$181,848
Used by mobile marine forces.



18) Deep Ocean Test-In-Place and Observation System for Naval Sea Floor Construction Support. TR 152. (YF 38.535.002.01.012)
$491,975
Used as a support system for many Navy projects (sediment testing, mooring, etc.).

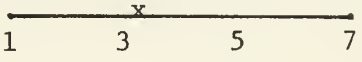


WORK UNIT DESCRIPTION

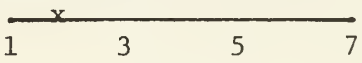
POTENTIAL FOR TRANSITION ONLY (5 total)

The "x" on the scale that is marked from one to seven, which accompanies each work unit description, is used to display the technology transfer effort associated with that work unit. The one on the left of the scale indicates low technology transfer effort while the seven on the right indicates high technology transfer effort.

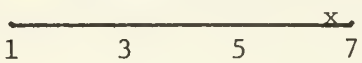
1) Critical Appraisal of the Technical Literature Dealing with Thin-wall Reinforced Concrete Pontoons, Corrosion of Steel Reinforcement in Concrete Exposed to Marine Conditions, and Cracking of Reinforced Concrete Exposed to Weathering.
TN 1447; TDS 77-03. (YF 53.534.001.01.023)
$19,911



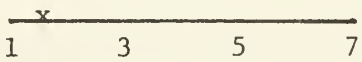
2) Air Pollution Episode Decision Processes for the U.S.N. (based on the military form of "Estimate of the Situation".
TN 1457*. (YF 57.572.002.01.014)
$32,244



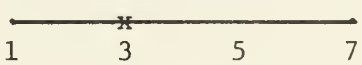
3) To Analyze, Develop, Test and Evaluate New Concepts for Earth Moving, Excavation and Land Clearing Related to Marine Corps Combat Operations. (YF 53.536.10m.01.004)
$207,948



4) To Increase the Efficiency and Speed with which Naval Construction Force Equipment is Operated While Decreasing Skill, Coordination, and Attention Required by Operator.
(YF 53.536.006.01.008)
$70,656



5) Develop a Construction Assistance Vehicle for Use by Sea Bees in Sea Floor Military Construction Operations. (YF 38.535.003.01.004)
$273,507



WORK UNIT DESCRIPTION

WORK UNITS THAT DID NOT TRANSITION (7 total)

The "x" on the scale that is marked from one to seven, which accompanies each work unit description, is used to display the technology transfer effort associated with that work unit. The one on the left of the scale indicates low technology transfer effort while the seven on the right indicates high technology transfer effort.

1) Experimental Hose Line for Adv Base Fuel Transport Over Deep Snow.
TR 814; TN 1027. (YF 53.536.003.01.012)
$26,572

1 x 3 5 7

2) Are Aluminum Frame Motors More Suitable for Use in Salt Fog Environments Instead of Cast Iron Frame Motors.
TN 1464. (YF 53.534.006.01.042)
$18,998

x
1 3 5 7

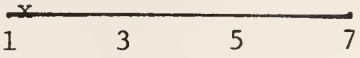
3) Investigation of the Hinging Mechanism in Under-Reinforced Concrete Beams Subjected to Static or Dynamic Loads.
TR 489; TN 901*. (YF 38.534.001.01.010)
$294,236

1 3 5 x 7

4) Develop the Hardware and Procedures Needed to Safely and Quickly Guide a Container Lowered by Crane onto the Standard Military Container Chassis or Flatbed Truck. TN 1313. (YF 53.536.005.01.016)
$60,229

x
1 3 5 7

5) Tests Evaluating the Driving Capabilities of the Rapid-Impacting Hydroacoustic Pile Driver. TN 1362. (YF 53.536.006.01.011)
$90,780



6) Develop Techniques and Equipment to Reduce the Exhaust Gas Pollutants from Navy Jet Engine Test Cells.
(FY 53.554.001.01.008) Progress Report 63-73-12 (NCEL)
$67,130

7) Comparing the Effectiveness of Thin Coatings to Control Corrosion. (YF 51.543.006.01.003)
$28,823